Zoogoer

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SEPTEMBER/OCTOBER 2007

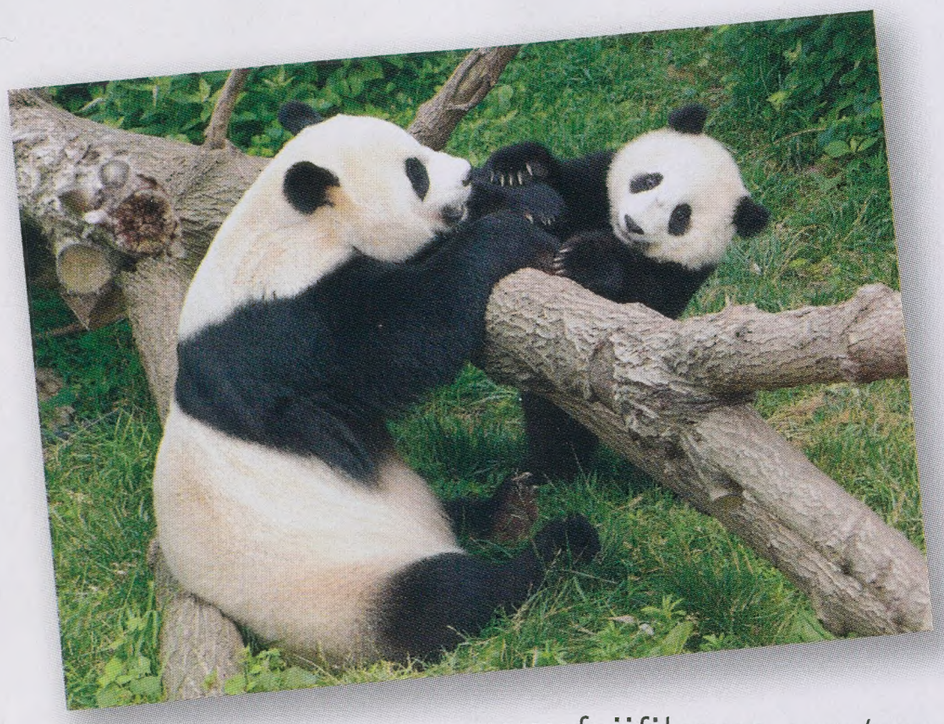
FUJIFILM

FONZ
Friends of the National Zoo

Smithsonian
National
Zoological
Park

Fujifilm, the Smithsonian's National Zoo and Friends of the National Zoo are working together to help protect giant pandas and secure their future through education and research.

Visit and enjoy giant pandas Mei Xiang, Tian Tian and Tai Shan at the Fujifilm Giant Panda Habitat as well as six other Asian species along the Asia Trail.



www.fujifilmusa.com/pandas

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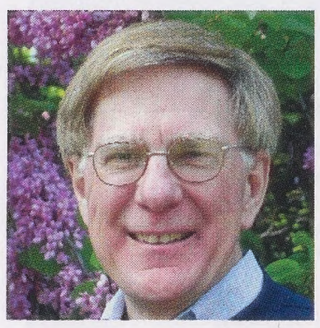
Greening Up



You may notice a subtle change in your next issue of *ZooGoer*, the first one printed on a new, even more environmentally friendly paper than before. The paper we have been using is ten percent post-consumer recycled fiber and up to 30 percent virgin recycled (which means the paper mill reuses the paper waste it creates). It is also elemental chlorine free, and our printer uses soy-based inks, the most ecofriendly available. While this is pretty good for the glossy stock that makes the color photography in *ZooGoer* "pop," we decided we could do better.

The new paper, called Utopia Two, is 30 percent post-consumer recycled fiber, three times that of the former paper, and is processed chlorine free. Equally important, the virgin fiber is certified by the Forest Stewardship Council (FSC). Recognizing that we will continue to rely on forests for wood to make paper, the FSC, an international nonprofit, promotes responsible management of those forests through its certification process. To earn certification, a forestry operation must adhere to ten management principles including conserving biodiversity, maintaining the conservation value of forests, and enhancing the economic and social well-being of workers and local communities. Further, to ensure the integrity of the process, wood from certified forestry operations must be tracked each time it changes hands from paper mill to printer; these operations are also certified. The mill that manufactures Utopia Two, and Stephenson Printing, Inc., which prints *ZooGoer*, are so certified.

This is but one example of how all of us at the Zoo are redoubling efforts to incorporate sustainable, environmentally friendly practices in everything we do. The award-winning sustainable design features of Asia Trail, including green roofs, solar hot-water heaters, and building materials such as bamboo and FSC-certified wood, will be a model on which all future exhibit projects will build. Among the "green" features planned for Elephant Trails, for instance, are renewable geothermal energy, solar power, stored rainwater for irrigation, and recycled building materials.

We are making a difference in many other ways, too. On Earth Day, many of you joined us in planting 1,000 new trees in the Zoo. Our national Stomp Out Carbon contest raised awareness of how people can reduce their carbon footprint to help curb global warming. Staff recycle paper, cardboard, printer cartridges, fluorescent tubes, cans, and bottles, and we continue to test ways to encourage Zoo guests to recycle during their visit.

Our restaurants are doing their part, too. Plates, napkins, and other paper products include recycled fiber. Utensils are made of corn, not plastic! No palm oil or trans fats are used in food items. All coffee served at the Zoo is Bird Friendly, which is certified as coming from farms that provide forest-like habitat for birds and is organic, based on criteria established by the Zoo's Migratory Bird Center.

To learn more about our sustainability efforts, and find tips for what you can do at home and in the office to live more sustainably, go to **www.fonz.org/greentips.htm**. Working together, we can create a brighter future for ourselves and the natural world around us.

Sincerely,

Bob Lamb

Bob Lamb
Executive Director, Friends of the National Zoo

FONZ Friends of the National Zoo is the dedicated partner of the Smithsonian's National Zoological Park. FONZ provides exciting and enriching experiences to connect people with wildlife. Together with the Zoo, FONZ is building a society committed to restoring an endangered natural world. Formed in 1958, FONZ was one of the first conservation organizations in the nation's capital.

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Smithsonian **National Zoological Park** is located at 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537. Weather permitting, the Zoo is open every day except December 25. For hours and other information on visiting the Zoo, go to **www.fonz.org**.

Membership in FONZ offers many benefits: programs, publications, discounts on shopping and events, free parking, and invitations to special programs and activities to make zoogoing more enjoyable and educational. To join, write FONZ Membership, FONZ, P.O. Box 37012 MRC 5516, Washington, D.C., 20013-7012, call 202.633.3034, or go to www.fonz.org/join.htm.

Membership categories and annual tax-deductible dues are:

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($8 of membership dues goes to a *ZooGoer* subscription)

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An audio version of *ZooGoer* is available on our website, for members who cannot read standard print due to disability. For more information, please visit **www.fonz.org/zoogoer.htm.**

On the cover: A Wahlberg's epauletted fruit bat (*Epomophorus wahlbergi*) feeds on a mango. There are more than 5,400 species of bats worldwide that feed on a great variety of foods, including fruit, nectar, fish, and birds. Photo by Merlin D. Tuttle/Bat Conservation International/batcon.org.

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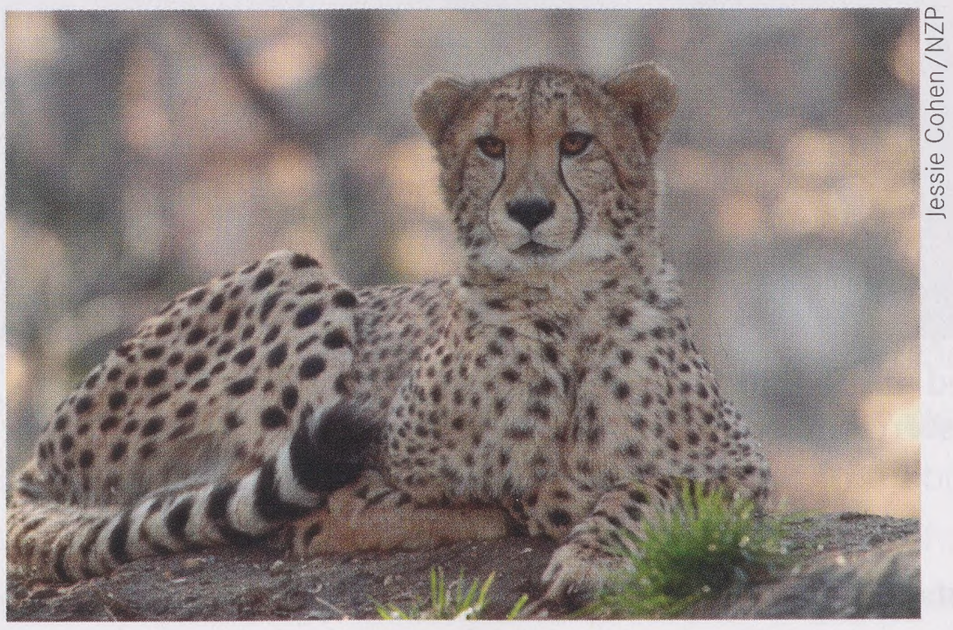
Country Cheetahs

At the end of September, we will celebrate the opening of our new Cheetah Science Facility at our Conservation and Research Center (CRC) in Front Royal, Virginia. The sprawling nine-acre facility is set in a secluded, quiet part of CRC, where eventually as many as 20 cheetahs may live and breed. The new facility will also be the home base of a comprehensive program to study and conserve cheetahs here and in Namibia, in partnership with the Cheetah Conservation Fund based there.

This is exciting news on so many fronts. The cheetah facility represents the first new construction at CRC in 25 years. A few years ago, CRC's situation was precarious and there was talk of its being closed. Fortunately, this didn't happen. The Smithsonian's National Zoo was able to hold on to this 3,200-acre jewel—a bucolic blend of forest and field, streams and springs, and historic buildings and barns at the edge of Shenandoah National Park.



Jessie Cohen/NZP

Now we are poised to develop new programs, expand the central campus, add new animal areas, and welcome new partners to join us in making CRC the most dynamic, scientifically productive conservation center of its kind. At the same time, we are studying how to offer more opportunities for FONZ members and the public to experience CRC.

To move toward these goals, we are in the process of finalizing a draft master plan for CRC. The challenge in developing the master plan is to expand and open the site to more professionals, students, and members of the public without compromising the rural enclave's ecological research and natural biodiversity monitoring or disturbing the relative isolation of sensitive animals like cheetahs. We also have to carefully consider CRC's place in the landscape, which is still largely rural but experiencing increasing development. And, of course, we are committed to sustainable, ecofriendly design and practices. I'll have more to share with you on the CRC plan in the near future.

It's also exciting that the new Cheetah Science Facility and its research programs hold great promise for saving cheetahs. They are vulnerable to extinction, with declining numbers living in scattered, isolated populations in sub-Saharan Africa. What's more, no "insurance policy" exists against their extinction in the wild because the zoo population is not self-sustaining. We still lack the biological information and husbandry skills to promote consistent reproduction among zoo cheetahs in North America, or anywhere.

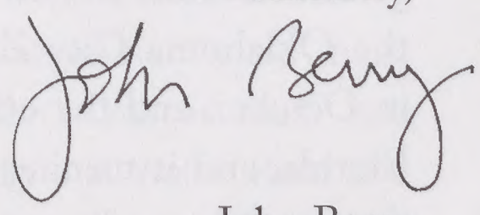
We are hoping that the low-stress seclusion of the new facility coupled with insights gained from our intensive research on behavior, reproduction, and health will quickly change that. Plus, the large number of individuals will let the cats select compatible mates and have plenty of space for natural social and physical activity. Research on cheetahs at the Cheetah Conservation Fund's facilities in Namibia will add to our knowledge, increase opportunities for exchange to maintain the zoo population's genetic diversity, and help us link cheetahs in zoos to those in the wild. And this is just part of our program, which also includes education and outreach activities.

Thanks to generous supporter Bill McClure, we had funding for the construction of the Cheetah Science Facility. In the next few months, you will receive in your mailbox an appeal to help us fully develop the cheetah research and conservation program. I hope you give generously to support this important initiative.

And I look forward to seeing you at our Autumn Conservation Festival (ACF) held at CRC on the weekend of October 6 and 7. At present the only time CRC is open to FONZ members and the public, the ACF offers a fun-filled opportunity for families to visit CRC's beautiful historic campus and learn about our work there to study and conserve clouded leopards, red pandas, Eld's deer, Przewalski's horses, and more. It will also be a chance to hear more about our cheetah plans, although the new Cheetah Science Facility is too remote to visit in person. Look for more information about the ACF at **http://nationalzoo.si.edu/goto/acf** and plan to spend a fabulous day in the country.

I'll see you there! Thanks for your continuing support of the Smithsonian's National Zoo.

Sincerely,



John Berry
Director, Smithsonian's National Zoological Park

Jessie Cohen/NZP

Kori bustard chicks Pipe and Tuza hatched at the Smithsonian National Zoo's Bird House in late June. Kori bustards are the world's heaviest flying birds and are native to eastern and southern Africa.

Animal News

In late June and early July, four **kori bustard chicks** (*Ardeotis kori*) hatched at the Smithsonian National Zoo's Bird House. Their names—Tuza means "honor," Pipe means "sugar-drop," Nadra means "rare," and Rasi means "leader"—are Swahili, one of the languages spoken in kori bustards' native habitat in eastern and southern Africa. Kori bustard populations in the wild are threatened by overgrazing, agricultural development, and poaching, and have been extirpated from some parts of their native range. The Zoo breeds kori bustards under the auspices of an Association of Zoos and Aquariums Species Survival Plan (SSP), and nearly 40 chicks have hatched here in the last decade. Zoo scientists also conduct field work and reproduction studies to help protect kori bustards from further decline.

Two young male **Grevy's zebras** (*Equus grevyi*) went on exhibit at the Cheetah Conservation Station in August. One came from the Oklahoma City Zoological Park and will be two years old in October, and the other came from Busch Gardens in Tampa, Florida, and is turning four in September. Grevy's zebras are endangered due to livestock grazing, limited access to water sources, and hunting. Experts estimate that the worldwide population has been reduced to about 3,000 individuals living in Kenya and Tanzania. The Zoo assists the SSP for Grevy's zebras by housing juvenile males until they are old enough to breed at other zoos.

The Zoo's Conservation and Research Center (CRC) in Front Royal, Virginia, will take a big step forward in cheetah conservation this fall with the opening of its Cheetah Science Facility. Up to 20 **cheetahs** (*Acinonyx jubatus*) will live in the nine-acre facility, which is designed to provide an ideal environment for breeding and cub-rearing. Keepers and scientists will conduct research on cheetah reproduction, endocrinology, behavior, nutrition, and genetics at the facility, and will also train fellows, students, and interns in conservation science. This project is the first construction to take place at CRC in 25 years, and is made possible by Bill McClure, a long-time friend of the National Zoo.

The Zoo announced in July that female **giant panda** (*Ailuropoda melanoleuca*) Mei Xiang would not give birth to her second cub in 2007. Mei Xiang was artificially inseminated with sperm from Gao Gao, one of the San Diego Zoo's male giant pandas, in April. Zoo scientists and veterinarians carefully tracked her hormones and behavior over the following months. On June 28, her hormone levels suggested that she was either preparing to give birth or reaching the end of a pseudopregnancy, a phenomenon commonly experienced by female giant pandas that ovulate but fail to conceive. Ultrasounds revealed no sign of a fetus, and the Zoo concluded that she had experienced a pseudopregnancy. Zoo scientists will determine whether Mei Xiang should be considered for breeding in 2008.

Events

For more information, visit **www.fonz.org/events.htm**.

Mehgan Murphy/NZP

Fiesta Musical

September 16—11 a.m. to 5 p.m.

Latin American culture and wildlife take center stage at Fiesta Musical, a free, family-friendly event that celebrates Hispanic Heritage Month. Highlights include live music and dance performances, keeper talks, and scrumptious Latin American foods. For more information, visit **www.fonz.org/fiesta.htm**.

Escape to the Wild Side

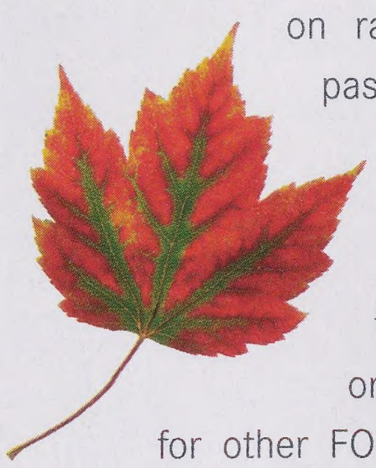
September 28—7 to 10 p.m.

You're invited to a gala evening at the National Zoo featuring a lecture by Emmy-winning wildlife biologist Jeff Corwin, followed by cocktails and hors d'oeuvres along the Zoo's Asia Trail. Proceeds from this fundraiser, which is cohosted by the Smithsonian Institution Libraries (SIL), FONZ, and the National Zoo, will support the SIL and the Zoo's wildlife conservation programs. Tickets are $250 per person for general admission and $500 per person for VIP admission, which includes a reception with Corwin. For more information, visit **www.escapetothewildside.org** or call the SIL at 202.633.2875.

Autumn Conservation Festival

October 6 and 7—10 a.m. to 3 p.m.

The Zoo's Conservation and Research Center (CRC) in Front Royal, Virginia, invites your family to a once-a-year, behind-the-scenes look at its conservation and science programs. Enjoy fun activities, guided tours of animal facilities, and live music. Lunch and beverages will be sold on the grounds. The event will go on rain or shine. Parking passes are required and are free for FONZ members who are CRC donors or are at the Contributing level or higher; they are $25 for other FONZ members and the public. To add a CRC donation to your membership or obtain a parking pass, visit **www.fonz.org/acf.htm**.



FONZ Annual Meeting

October 16—6 to 7:30 p.m.

Join us for the 49th FONZ Annual Meeting. The evening begins with a wine-and-cheese reception with FONZ Board members, followed by the introduction of new Board members and officers and voting on changes to the bylaws. FONZ President Robyn Kravit will also give a "state of FONZ address."

Boo at the Zoo

October 26, 27, and 28—5:30 to 8:30 p.m.

Bring your little monsters who are 12 or younger to Boo at the Zoo for a night of trick-or-treating at more than 40 treat stations. Not-too-scary haunted trails and animal houses, interpretive talks about some of the Zoo's creepiest creatures, and ghoulish decorations make for festive fun at the wildest Halloween party in town. Proceeds from Boo at the Zoo support public education programs at the Zoo. For more information on this very popular event, visit **www.fonz.org/boo.htm**.

FONZ's 50th Birthday

2008

We're getting ready to celebrate 50 fabulous years of connecting people with wildlife. Please share your memories and photographs of FONZ at **www.fonz.org/fonzmemories.htm**.

Denise Kappa/iStockphoto.com

We want to know what you think of *ZooGoer*! Please go to **www.fonz.org/zoogoersurvey.htm** to fill in a short survey about the magazine's look and content.

Volunteer Corner

Dan Boritt/NZP

Laurie Bay volunteers as an Exhibit Interpreter at the Bird House.

Laurie Bay volunteers in the Zoo's Bird House, but she doesn't roost in one place for long. She also volunteers in two other Zoo programs—Kids' Farm and How Do You Zoo?—and before she moved to Washington, D.C., she traveled the world for 11 years in the military, most of the time as an anti-aircraft artillery officer.

Laurie's long-time interest in animals and nature led her to study agriculture and animal husbandry in college. She draws on that background when she's an interpreter at Kids' Farm, sharing information with children about where their food comes from. She also shows young people what it's like behind the scenes at the Zoo as a How Do You Zoo? interpreter, and offers visitors a chance to touch feathers and eggs at the Bird House.

Laurie also volunteers at the Smithsonian Natural History Museum's Kenneth E. Behring Family Hall of Mammals. In her "spare" time, she coaches her son's soccer team and makes quilts for soldiers at Walter Reed and patients in the neonatal intensive care unit at Holy Cross Hospital. The variety and activity in her life keep her going because, she says with a smile, "The person who has the most fun wins!"

—Molly Woods

Illuminating

Secret Shadows

by Don E. Wilson

As if small migratory birds didn't face enough travail on their seasonal journeys, a new predator on some of these avian sojourners has recently been identified by a team of Spanish scientists. Millions of songbirds that breed in Europe funnel through the Iberian Peninsula en route to winter havens in Africa. As they fly high in the sky in the dark of night, they risk becoming the victim of another winged creature—a bat with a wingspan as wide as 18 inches and long, sharp canine teeth, according to a study published by Spanish and Swiss scientists this year in the journal *PLoS ONE*.

One of the largest bats in Europe, the giant noctule (*Nyctalus lasiopterus*), is also one of the few bats known to eat birds. What's more, it is the only animal that snatches birds out of midair at night and, scientists believe, somehow manages to eat them on the wing. (This occurs so high, and in such darkness, that no one has seen it happen—but it must.) All other bats known to eat vertebrates, such as frog-eating bats, tackle their prey on the ground or other substrate. All other bats known to catch prey on the wing, a foraging pattern called aerial hawking, hunt flying insects, as the giant noctule does between its seasonal songbird feasts.

A greater horseshoe bat (*Rhinolophus ferrumequinum*) deftly maneuvers the night sky in pursuit of a moth. Bats are often cast as mysterious or frightening, but there is more cause to celebrate them as pollinators, seed dispersers, and insect consumers than to fear them.

This finding astonished the scientific community (or at least that part of it concerned with bats and birds). But to Peter Marra, of the Smithsonian National Zoo's Migratory Bird Center, "It makes complete sense. There's so much biomass it's not really surprising that there's a species taking advantage of it."

Taken in the context of all the world's bats, however, it's hardly surprising that the giant noctule has evolved to fill an unusual ecological niche—after all, there are a huge number of bats and they occupy every terrestrial ecosystem on Earth except for extreme polar regions. In the most recent (2005) edition of *Mammal Species of the World*, which Dee Ann M. Reeder and I edited, we listed a total of 5,416 species of mammals. Of these, 1,116 are bats; only rodents boast a larger diversity of species.

For example, the genus *Myotis*, sometimes called little brown bats or mouse-eared bats, is more broadly distributed than any other terrestrial mammal genus. These relatively small insect-eaters occur from Alaska to Labrador and from Norway to eastern Siberia. They range southward to Chile and Argentina in the New World, and as widely as Southeast Asia, Australia, and Africa, to the Cape of Good Hope, in the Old World. *Myotis* also represents an ancient, primitive lineage of bats: There are *Myotis* fossils from Europe dating to the Eocene (52 to 34 million years ago), when early bats rapidly diversified. *Myotis* is therefore the most widespread genus of bats in both space and time. The familiar little brown myotis (*M. lucifugus*) lives throughout North America and is the continent's most abundant bat species.

Eric Baccega/naturepl.com

A little red flying fox (*Pteropus scapulatus*) stretches its wing. The *Pteropus* genus includes the world's largest bats.

Bats range in size from some of the smallest known mammals to giants with wingspans as wide as some adult humans are tall. The world's smallest bat, the hog-nosed bat (*Craseonycteris thonglongyai*), was discovered in Thailand in 1973. It weighs less than a penny and could rest comfortably on two fingers of your hand. The largest are the so-called flying foxes, which are not actually foxes but fruit-eating bats (*Pteropus* spp.) with wingspans of up to five feet. The hog-nosed bat and some species of flying foxes live in Southeast Asia, where the diversity of bats is very high, second only to that found in the tropics of South America (although no flying foxes live in the New World.)

Bats also have a variety of food habits. In addition to the many species that eat insects or fruit, others specialize on sipping nectar from flowers; hunting fish, frogs, or a variety of small vertebrates; or even feeding solely on blood, as three species of true vampire bats do.

Despite their incredible diversity and distribution, bats are generally so little-known that the scientists who study them discover new things all the time. Much about them remains mysterious, even though we now understand a great deal more about their biology than we did in the 1960s, when my own interest in them began.

Kim Taylor/naturepl.com

Common pipistrelle bat (*Pipistrellus pipistrellus*).

Flying Machines

Although it is fascinating to watch bats as they hang upside-down in their roosts, it is on the wing that these animals become truly impressive. If you have ever watched a small bat deftly circling the trees in your backyard as it catches insects on the fly, you must have marveled at its ability to change directions, avoid obstacles, and intercept prey. Flight is the single characteristic that sets bats apart from all other mammals, and there are no flightless bats.

Fringe-lipped bat (*Trachops cirrhosus*).

Bats belong to the order Chiroptera, a name meaning "hand wing" in Latin, because the bones of a bat's elongated fingers, along with its forelimbs, support the membranes of its wings. Another interesting evolutionary modification is that bats' knees are rotated 180 degrees from those of most mammals. So, if they are hanging upside-down with their bellies toward the wall, they can take flight immediately by simply dropping and flapping away.

Although both birds and bats fly by flapping their wings, bat flight is considerably different from bird flight, or any other animal flight, for that matter. The unique attributes of bats' flexible wing membranes yield flight characteristics that would be very useful to human-designed flying machines, an international team of scientists reported in *Science* this year.

G. R. Spedding, an aerospace engineer at the University of Southern California in Los Angeles and a coauthor of the study, outlined an exciting research program to make detailed measurements of bat wings and add to a growing body of data about bat flight. "Bats are agile hunters, capable of plotting and executing complex maneuvers through cluttered environments," he said. "These are the traits we'd like our unmanned air vehicles to have because there are so many complex rural and urban environments in which we could use them."

Bats and Echolocation

Bats are not blind; they can see as well as we can, and better than some mammals that spend most of their time underground. However, most species have essentially supplanted vision with echolocation, a process of sending out pulses of high-frequency sound and using the returning echoes to detect objects and to navigate. This allows them to specialize on haunting the same dark night skies that also shroud them in mystery. Echolocation is so foreign to our own experience that we have trouble even conceiving of it. Yet the images formed in the brains of echolocating bats are probably not terribly different from the images our brains form from our own visual system.

Bats' exceptional ability to orient themselves with their hearing rather than their vision was first demonstrated in a series of elegant experiments performed in 1793 by an Italian scientist named Lazaro Spallanzani. He inserted small tubes into the ear canals of bats so that, by stopping up the tubes, he could block their hearing. He showed that the bats became disoriented and less able to avoid obstacles with even one ear plugged.

But the idea that bats produce ultrasonic sounds was not confirmed until about 70 years ago, when a Harvard biology student named Donald Griffin used an extremely sensitive microphone to detect bats' high-frequency calls and show that the rate of their calls increases as they approach obstacles. Since then, the study of echolocation has played a prominent role in our efforts to learn more about bats and how they have adapted to their environments. Scientists now use an electronic apparatus known as a bat detector to distinguish between bat calls and translate them into audible signals for analysis.

The evolution of echolocation has led to bats having a very complex inner-ear anatomy, which gives them supersensitive hearing. A group of bats called foliage gleaners listen for the very faint noises large insects make as they move about on the ground, or on the surface of vegetation. By homing in on these sounds, which we cannot hear, they easily locate their evening meals.

Most species have essentially supplanted vision with echolocation, a process of sending out pulses of high-frequency sound and using the returning echoes to detect objects and to navigate.

These sophisticated listening skills can lead to some startling adaptations. A 2006 study published by German scientists Udo Gröger and Lutz Wiegrebe of Munich's Ludwig-Maximilians-Universität shows how common vampire bats (*Desmodus rotundus*) suck blood from the same people night after night. The scientists' experiments demonstrated that the bats can detect differences in the breathing sounds of three sleeping human subjects. By listening to potential prey and detecting its heat in the form of infrared radiation, the bats can discriminate between individuals.

Bat Social Systems

The social systems of bats are as varied as the places they live and the foods they eat. Some species live in huge colonies. Millions of pregnant female Mexican free-tailed bats (*Tadarida brasiliensis*), for example, roost together in Bracken Cave near San Antonio, Texas, each spring. When the females give birth in early summer, the population of the cave rises to an astounding 20 million individuals—the largest known maternal bat colony in the world. Other species, such as the eastern red bat (*Lasiurus borealis*), are solitary, and males and females come together only to breed.

Some species form harems in which groups of females roost together and are attended by a single male. By huddling together, harem females maintain a consistent body temperature, allowing them to conserve energy for flying and pup rearing. And unlike solitary or colony-roosting bats, harem females enjoy protection by their attending male from predators and other suitors.

Social dynamics within harems can be simple or quite complex. Female spear-nosed bats (*Phyllostomus hastatus*), for example, tend to remain loyal to one harem for years at a time, but female Jamaican

Merlin D. Tuttle/Bat Conservation International/batcon.org

A female Gambian epauletted fruit bat (*Epomophorus gambianus*) wraps her wings around her young pup as they roost in a tree.

fruit-eating bats (*Artibeus jamaicensis*) switch harems more frequently. In 2006, National Zoo geneticist Jesús Maldonado and Jorge Ortega from the Instituto de Ecología in Mexico published a study of the social dynamics of Jamaican fruit-eating bat harems. They discovered that females roosting in the central core of the harems were dominant over females in the middle or outskirts. These fortunate females were groomed and licked more frequently by the females in the middle than other members of the harem, while those on the outskirts were subjected to more aggressive behavior such as wing flicks and grunts and were more often expelled from the harem by the females in the middle than any other members of the group.

Biologists from the United Kingdom reported in *Nature* in 2005 that greater horseshoe bats (*Rhinolophus ferrumequinum*) have a mating system that seems a bit bizarre to us. Mothers, daughters, and grandmothers sometimes mate with the same male, leading to some curious relationships. Using sophisticated genetic techniques, the scientists showed that a female and her maternal half-aunt were also half-sisters on their father's side. Despite these tangled familial ties, which increase the number of ancestors that individual greater horseshoe bats have in common, the study's authors found no similar increase in the level of inbreeding in the species.

A bat's social system, and especially its mating systems, may have interesting effects on its anatomy. Gerald Wilkinson of the University of Maryland, College Park, Scott Pitnick of Syracuse University in New York, and Kate E. Jones of Columbia University in New York found that "in species in which females are promiscuous, males have larger testes and smaller brains proportionate to their body size than in species in which the females are more faithful. For instance, female silver-tipped myotis (*Myotis albescens*) are promiscuous, and males have testes that comprise 6.7 percent of their body weight, while their brains comprise only 3.2 percent. This suggests there is an evolutionary price for successful mating when females can choose among many mates. The same principle has been linked to primates as well: Chimpanzees, for example, are promiscuous and the males have relatively larger testes than male gorillas, which maintain harems of dependent and faithful females.

Regardless of their mating system, male bats don't contribute to caring for their pups—in fact, paternal care has been documented in only two species. As in all mammals, female bats feed their young with milk produced by their mammary glands. Pups are born blind and naked, and require a month or two of maternal care, with daily bouts of nursing.

Mother bats go out and forage each night, and almost always leave their pups behind in the roost. On their return, they may use a variety of complicated signals, including high-frequency vocalizations, to relocate their own young from among what may be thousands of others if they live in a large colony. In 2006, German scientists from the University of Erlangen-Nuernberg in Erlangen, Germany, published a study of mother-young communication in the journal *Naturwissenschaften*. The scientists discovered that baby sac-winged bats (*Saccopteryx bilineata*) attempt to mimic their parents' vocalizations by making nonsense sounds that are probably comparable to the babbling of human babies.

Regardless of their mating system, male bats don't contribute to caring for their pups—in fact, paternal care has been documented in only two species.

Roosting Habits

Although you may see bats whispering their way through the summer nighttime skies, most of them spend the daytime resting in secluded roosts. The most common type of day roost is caves, and

Caves offer many species, such as these Mexican long-tongued bats (*Choeronycteris mexicana*), protection from harsh weather, and their consistent temperatures help roosting or hibernating bats conserve energy.

Merlin D. Tuttle/Bat Conservation International/batcon.org

A hibernating greater horseshoe bat.

most families of bats have at least some species that frequent them whenever possible. Caves protect bats from the sun and predators, and their relatively constant temperature and moisture conditions help bats conserve energy.

Bats control their body temperature by a process called facultative heterothermy: As the ambient temperature falls, they can allow their body temperature to decrease until they go into a state of inactivity called torpor. They may do so daily, dropping their body temperature to match those of their cool day roosts. In addition, bats of many temperate-zone species sleep the winter away in hibernation torpor. An active bat's body temperature may range from 95 to 104°F, but it can fall as low as 32°F in hibernation. Maintaining a constant body temperature is energetically costly for mammals, so bats save significant amounts of energy through daily and hibernation torpor.

Another result of spending half or more of the year in hibernation might be an extended lifespan. Compared with most small mammals, bats are amazingly long-lived: In general, they tend to live 3.5 times longer than comparably sized small mammals in other orders, according to a study by the University of Maryland's Gerald Wilkinson and Jason M. South that was published in *Aging Cell* in 2002. Some individuals may live for 30 or more years (although the average life span is undoubtedly much shorter than that). The maximum age varies greatly from species to species and is heavily influenced by geography. For instance, the study's authors noted that a male Brandt's bat (*Myotis brandti*) from Siberia holds the longevity record of 38 years, and 23 other males from this area lived 25 years or more. They suggest that the duration of hibernation, which lasts longer the higher the latitude, may increase longevity compared with bats that have shorter hibernations.

Bat Conservation

Threats to bat species are increasing globally due to the relentless onslaught of human activities, including habitat destruction, which limits foraging areas and roosting sites for bats worldwide. Although some bat species have adapted well to humans and their environmental modifications, most have not. For every species like the common little brown myotis of North America, which takes advantage of man-made structures like attics, barns, and other buildings for roosting sites, there are many more that find human encroachment on their natural habitats incompatible. The World Conservation Union's (IUCN) Red List includes 1,024 bat species—almost all of them—as being of some conservation concern. Excluding those deemed of "least concern" still leaves 546 species, of which 172 are called vulnerable, 44 endangered, and 32 critically endangered. Nine species are listed as extinct, a number that will likely grow.

At the annual meeting of the American Society of Mammalogists in June 2007, Smithsonian's National Museum of Natural History scientists Lauren and Kristofer Helgen reported on two newly identified species of flying foxes that once occurred on Samoa. Known only from museum specimens collected in the mid-19th century, these two join at least three other species of flying foxes that have gone extinct on Pacific Islands due to expanding human populations.

On the other hand, conservation action can stem such losses. My colleague, John Engbring of the U.S. Fish and Wildlife Service, and I studied another Samoan flying fox (*Pteropus samoensis*). This species is exceptional among bats because it is not nocturnal; instead, it forages over the small islands of Samoa during the daytime, searching for trees with ripe fruit. This unusual diurnal feeding behavior has likely evolved because of a lack of predators on Samoa, at least until humans arrived there.

When John and I were studying these flying foxes in the late 1970s and early '80s, their numbers were in severe decline, because people were harvesting and selling them in markets as food. Many were exported to Guam as delicacies. Protection under the Convention on International Trade in Endangered Species, which prohibited this trade, has allowed their populations to recover, albeit slowly, in the face of natural disasters such as typhoons, which have been increasing in frequency.

Millions of Mexican free-tailed bats emerge from Bracken Cave in Texas each evening in spring and summer.

Merlin D. Tuttle/Bat Conservation International/batcon.org

Merlin D. Tuttle/Bat Conservation International/batcon.org

A lesser long-nosed bat (*Leptonycteris yerbabuenae*) feeds on the fruit of an organ pipe cactus. Some plant species depend on pollination by bats, and could not survive without them.

Although people pose a much greater threat to bats than the reverse, bats are associated with diseases transmissible to humans. Rabies, a viral infection of the central nervous system, is by far the biggest public health concern. Like all mammals, bats are capable of contracting rabies; they also suffer the symptoms of the disease and eventually die from it. The disease can manifest itself in two distinct ways: as paralytic or as furious rabies. Animals with paralytic rabies become immobilized and may seem less threatening even though they are equally dangerous. Animals with furious rabies may wander dazedly, biting fiercely at whatever they encounter. Bats rarely exhibit this form of the disease and typically bite only if handled.

Recent research also implicates some bat species as carriers and transmitters of emerging zoonoses, which are animal-borne diseases that can be transmitted to humans. These diseases are appearing as a result of both climate change and our increasing encroachment on animal habitats, which brings animals and people in greater contact. Three species of horseshoe bats (*Rhinolophus* spp.) carry the virus that causes Severe Acute Respiratory Syndrome (SARS), while other bat species are natural hosts of the Nipah and Hendra viruses that recently hit people in Asia and Australia. This argues strongly for an enhanced research program on bats, although by some estimates, fewer than two percent of human pathogens are found naturally in bats.

> Threats to bat species are increasing globally due to the relentless onslaught of human activities, including habitat destruction, which limits foraging areas and roosting sites for bats worldwide.

Greater understanding of bats and how they interact with their environments is critical to human health as well as to the continued existence of bats in all their diversity. Apart from their small role in carrying human pathogens, bats provide us with many ecosystem services, such as eating insect pests and pollinating important food plants— including the plant from which tequila is made. So raise a toast to bats as they grace the late summer skies, eating the mosquitoes we are only too willing to share. Z

—Don E. Wilson is a senior scientist and curator of mammals at the Smithsonian's National Museum of Natural History in Washington, D.C.

A Wallace's flying frog (*Rhacophorus nigropalmatus*) glides from the canopy of a Bornean tropical forest. For some animals, gliding is the most efficient, and possibly the safest, way to travel from tree to tree.

gliders of the forest

by Mary-Russell Roberson

When English aviation pioneer Sir George Cayley launched his first gliding airplanes in the early 1800s, and put subsequent inventors on the path to achieving successful powered flight, it's unlikely that he'd ever seen a "flying" lizard. Yet Cayley's "governable parachute," which in 1853 glided 900 feet carrying his coachman, does bear passing resemblance to gliding reptiles such as the flying lizards of Southeast Asia.

Before Cayley, inventors including Leonardo da Vinci sought to build airplanes with flapping wings, modeled on birds. In flapping flight, wings provide both lift and thrust. Cayley's key insight was to separate the two functions—stable airplane wings provided lift, while a separate mechanism provided thrust. (He predicted, correctly, that powered flight would not be possible until the invention of a lightweight engine.)

In 1853, Cayley's governable parachute was pulled downhill until it was going fast enough to achieve lift. Today, hang gliders launch themselves off cliffs or other high points and let gravity provide the necessary velocity. That's pretty much the same way that gliding animals, including so-called flying lizards, do it.

Kim Taylor/naturepl.com

The southern flying squirrel (*Glaucomys volans*), pictured here, and the northern flying squirrel (*G. sabrinus*) are the only gliding mammals in North America. Both are nocturnal and although they're rarely seen by people, they are regular visitors to suburban bird feeders.

Gliding animals leap or fall from a tree and use anatomical and behavioral features to form "wings" that allow them to descend at a gentler angle than if they were simply falling. Once airborne, explains Robert Dudley, a leading authority on gliders, "All of these animals can reorient and control where they go to some extent. It's controlled aerial behavior." Dudley is a professor in the department of integrative biology at the University of California at Berkeley and a scientist at the Smithsonian Tropical Research Institute in Panama.

Just as gliding principles proved far easier to apply to developing airplanes than true, flapping flight, so too it appears that gliding is easier for animals to evolve. Flapping flight has evolved independently only four times: in bats, birds, insects, and pterosaurs—reptiles that went extinct about 65 million years ago. In contrast, gliding has evolved independently at least 30 times. Among the non-avian vertebrates, there are "flying" lizards, frogs, snakes, squirrels, possums, and even fish.

Except, obviously, for flying fish, all the known gliders live in forests and are arboreal. This just makes sense. Animals that live in trees occasionally fall: They slip, are startled, are pushed, or attempt an ill-advised jump. Individuals that have a bit more control over the speed or direction of a fall, versus simply crashing to the forest floor at high speed, are more likely to survive and pass on their genes. Over time, adaptations for full-fledged gliding may evolve, particularly if gliding confers other advantages, such as increasing the efficiency with which animals move among the trees, or enabling them to more easily flee from predators.

Curiously, though, gliding vertebrates have not evolved to the same extent in all forests. African and Central and South American tropical forests are home to only a handful of gliding species, mostly squirrels and frogs. Southeast Asian tropical forests, however, are glider heaven.

The Makings of a Glider Heaven

Dudley believes that several features of Southeast Asian tropical forests encourage the evolution of gliding. One is that the forest canopy is typically higher than in African or Central and South American tropical forests. Trees in the Dipterocarpaceae family make up much of the Southeast Asian forest, and they commonly reach heights of about 200 feet or more. Trees that tall are rare in African and American tropical forests, which usually have a canopy about 100 to 150 feet high. Tall trees are good for gliding because the higher up an animal is when it starts a glide, the more horizontal distance it can cover, which makes for a longer trip. Furthermore, a gliding animal needs to attain a certain falling velocity in order to generate sufficient lift. The higher the tree, the more time and space the animal has to reach the necessary velocity during the initial dive.

Calm air also makes for good gliding. Southeast Asian forests tend to be calm, although not necessarily more so than other tropical

forests. "There's not much wind below the canopy in any tropical forest, Dudley says. "It's windy at the top, but there's a gradient and it diminishes pretty quickly," although he adds, "All of these gliders can compensate for short-scale wind fluctuations."

Another structural feature of Southeast Asian forests that might encourage the evolution of gliding is the lack of connection between trees. Jim McGuire, who is an assistant professor of integrative biology at the University of California at Berkeley and a curator of herpetology at the university's Museum of Vertebrate Zoology, explains, "The trees themselves tend to have very tall, unbranching trunks until you get way up into the crown; it's like a forest of poles. The crowns are less connected than in other forests. There are fewer vines and things that span the crowns of two trees, which would provide continuous connection, so you either have to jump or glide to get from one tree to another." The alternative—climbing down to the ground, walking to another tree, and climbing up—exposes animals to predators on the ground and is less energetically efficient.

Louise Emmons, an ecologist at the Smithsonian's National Museum of Natural History, and her colleague Alwyn Gentry first speculated in 1983 that the relative abundance of lianas, or vines, might influence how arboreal animals move through tropical forests. They noted that most gliders, which do not have prehensile tails that can grip objects, are Asian, while most prehensile-tailed animals are Central and South American (Neotropical); few of either are African. As McGuire pointed out, fewer vines linking the trees in Asian forests may encourage the evolution of gliding. In the Neotropics, there are more vines, but they tend to be fragile and often break, so animals using them to travel between trees may need the extra support offered by tails that cling to stronger branches. African tropical forests, on the other hand, have the greatest density of vines forming bridges between trees, and these vines are quite strong, so special adaptations like gliding and prehensile tails are less important.

Adaptations for Gliding

Gliders have evolved various anatomical mechanisms for gliding, all of which seem to increase the surface area of their bodies, which increases lift. For instance, a dozen or more species of frogs (genera *Rhacophorus* and *Polypedates*) and almost as many geckos (genera *Ptychozoon*, *Cosymbotus*, and possibly *Luperosaurus*, which have physical adaptations for gliding but have not been observed doing it) stretch out large webbed feet, or use flaps of skin on their arms and legs—the most common approach to gliding. Flying squirrels, a group scientists call the Pteromyini, glide with the help of a parachute-like membrane called a patagium that stretches between the forelimbs and hindlimbs. (The membrane in bats' wings is also called a patagium, but they use it for true flight rather than gliding; see page 8 for more on bats.) Flying squirrels heavier than two pounds, such as the wooly flying squirrel (*Eupetaurus cinereus*) of Pakistan, Afghanistan, and India, have an additional membrane between their hindlimbs and tail called a uropatagium.

Colugos, also known as flying lemurs, have a similar but more extensive membrane that stretches between the neck, limbs, and tail, and encloses the tips of fingers, toes, and tails. These Southeast Asian mammals are not rodents, as flying squirrels are, nor are they lemurs, which are found only in Madagascar. Instead, the two extant species—the Phillipine colugo (*Cynocephalus volans*) and the Sunda colugo (*Galeopterus variegates*)—form their own order, the Dermoptera, whose nearest relatives may be tree shrews (which they don't particularly resemble).

Like all gliding mammals, colugos are nocturnal, spending days sleeping in trees and nights foraging for fresh tree leaves. According to Greg Byrnes, a Ph.D. student at the University of California at Berkeley who studies Sunda colugos, "Most of the time you see them upside down," hanging from tree limbs in a similar posture to that of sloths. When they want to glide, they push off with their hindlimbs and stretch out their forelimbs. "On average, they probably glide about 35 meters [about 115 feet], but I've seen them glide much, much farther—100 or 120 meters [about 330 or 390 feet]," Byrnes says. "They move their tails around an awful lot when they are gliding. If they want to turn, they'll bank or collapse part of the membrane, folding their limbs on that side of the body. They'll collapse part of the membrane to squeeze through a small space and they'll open it up again."

Colugos glide from tree to tree in search of food. "On an average night they might glide eight to ten times," Byrnes says. "It's a very sporadic thing. They'll sit in a tree for an hour or more." Twice, Byrnes has seen a colugo land on the ground, a few feet short of the intended tree. "When they land on the ground, they're pretty helpless," he says. "They don't really look like they know how to run like a regular animal. They sort of flop to the tree and climb up it."

Flying Lizards

The 45 species of *Draco*—the so-called flying lizards—live throughout Southeast Asia, from southern China to Sumatra to the Philippines and almost to New Guinea. Their wings are formed by elongated ribs that support patagia. The lizards open and close these wings using modified intercostal muscles (the small muscles between ribs). Smaller wings extend from the throat. Both pairs of wings are used for mating and aggression displays, and for gliding.

Like all vertebrate gliders, when the lizards first jump off a tree, they

Jane Burton/naturepl.com

The webbing between a flying gecko's (*Ptychozoon* sp.) toes.

Tim MacMillan/John Downer Pro/naturepl.com

The flying lizard (*Draco volans*) glides by extending two winglike flaps of skin on its neck and two on its sides that are supported by its elongated ribs.

fall steeply to gather sufficient velocity to generate lift, then level off to a more gentle angle.

McGuire says that at the end of a glide "they make a braking maneuver, gain a little bit of altitude, and land softly on the tree of their choice. It's easy for them to glide between ten and 30 meters [about 30 to 100 feet], but they can go much farther depending on where they start." He says maneuverability is difficult to quantify, but adds, "I've seen a flying lizard take off from the top of a coconut tree and do three spins around the tree and land lower on the trunk."

McGuire and Dudley collaborated on a study of how glide performance varies with size among these lizards, which range in weight from three to 35 grams (0.1 to 1.2 ounces). "The ten-fold variation in body size has to have some implication for locomotor performance," McGuire says. All the lizards are essentially scale models of one another; from an engineering standpoint, this creates a problem for the bigger lizards. "In general, larger things need relatively larger wings to create aerodynamic forces. You have to offset a body mass with surface area," Dudley says. (This is what the uropatagium does for larger flying squirrels.) Larger lizards have more mass per unit of surface area than do smaller lizards, so McGuire and Dudley hypothesized the glide performance of larger lizards would be worse.

The scientists captured *Draco* lizards and conducted gliding experiments in the Malay Peninsula and Borneo. In an open field, they erected two poles—a take-off pole about six meters high (nearly 20 feet) and a landing pole about four or five meters high (about 15 feet). The poles were a little more than nine meters (about 30 feet) apart, which is about the distance between trees in a typical Southeast Asian tropical forest. In the wild, flying lizards glide between trees, never coming to the ground except to lay eggs. With this in mind, McGuire and Dudley figured the lizards would use the landing pole as a target. They encouraged the lizards to jump by tapping the take-off pole, and the lizards did indeed glide to the landing pole.

McGuire and Dudley found that the larger species of *Draco* did tend to have steeper glide angles than their smaller relatives, losing more height over a glide of a similar horizontal distance. This finding might shed light on how more than one species of flying lizard can inhabit the same patch of forest without competing for limited resources.

McGuire says the larger lizards, being worse gliders, need to generate more velocity to achieve lift—which means they need to have a longer initial dive. "The expectation is that they would not be able to initiate a successful glide from as low on the trees as smaller ones," McGuire says, so perhaps lizards divide up their habitat vertically, with larger lizards living higher up. This has not been conclusively demonstrated, but there is anecdotal evidence that it is the case.

Draco is the only lizard genus with such obvious wings, but McGuire says, "There are probably a lot of arboreal lizards that can generate lift while falling." By orienting their bodies and limbs, animals can produce a glide even with no obvious physical modifications. For example, green anoles (*Anolis carolinensis*), which live in the southeastern United States, have been shown to glide at a ratio of one horizontal foot to one vertical foot.

Flying Snakes

If it's surprising to learn that animals without patagia can manipulate aerodynamic forces with their limbs and tails, consider flying snakes. How can an animal with no wings, no webbing, and no

A paradise tree snake (*Chrysopelea paradisi*) flattens its body to increase surface area and generate lift.

Jake Socha

limbs possibly generate lift?

That's what Jake Socha, a researcher at Argonne National Laboratory near Chicago, wanted to know when he began studying snakes in the genus *Chrysopelea* for his Ph.D. research a decade ago. He spent time at the National University of Singapore, the Singapore Zoological Gardens, and the Bukit Timah Nature Reserve (also in Singapore) filming the snakes as they jumped off ten- to 15-meter-tall (about 35 to 50 feet) towers or buildings. Socha worked primarily with *C. paradisi* and *C. ornata*.

One at a time, he placed snakes on a branch at the top of the tower; often a snake would jump immediately to get away from Socha. If the snake didn't jump, Socha would tap on the branch or the snake's tail to encourage it.

Socha analyzed his videotapes and photographs and found that the snakes were flattening out in the air. When a snake is preparing to jump, it hangs in a loop from a branch. "It jumps up and away from the branch, and as it's jumping it starts to flatten out from the head all the way to the tail," he says. The width of the body doubles, and it becomes slightly concave underneath. After taking to the air, the snake draws its entire body into an "S" shape (in the horizontal plane). "It undulates, sending these waves down its body starting from head and going to tail," Socha says. He doesn't know exactly how the undulations help with the gliding. "We don't think that it aids in lift generation," he says. "We think it helps balance the snake in the air so it doesn't tumble over."

When the snakes flatten out, they not only change shape, they also increase their surface area. "Lift is all about deflecting air downward," Socha says, "and the more surface you have, the more air you can deflect downward." The snakes are able to increase surface area by moving their ribs and "unfurling" tiny folds of skin between their scales.

The snakes start off in a fairly steep dive of about 50 or 60 degrees, then level off as they speed up and produce more lift. The flattest part of the dive that Socha measured was about 12 to 13 degrees from horizontal. He says they tend to land tail-first on the ground. He hasn't worked out exactly how they land on branches, although he's seen a lot of them do it. "One thing is for sure—they don't hit their heads!" he says.

How far they can go depends on how high they start. The best performance of *C. paradisi* that Socha measured from the ten-meter tower was a glide of 21 horizontal meters (nearly 70 feet). The snakes can also maneuver, taking sharp turns in midair. Once, Socha says, he was working on a tower next to some woods. He strung up a sheet alongside the tower to block the snakes' view of the woods. One snake jumped off the tower and as soon as it passed the end of the sheet, it turned sharply toward the trees.

Although Socha is not currently doing research with flying snakes, he is taking a faculty job at Virginia Tech in Blacksburg, Virginia, in the fall of 2008 and plans to spend some of his research time there studying *Chrysopelea*. He hopes to learn how the snakes turn while gliding; he says some of the species of *Chrysopelea* don't seem to be able to turn as well as others. "I would definitely like to examine that from an aerodynamic view," he says. "What does the body do and how does it create the force required to make the snake turn?"

He has also become interested in the ecology of gliders. He'd like to implant some snakes in the wild with radio transmitters and track them. "I'm dying to do an ecological study," he says. "There has been no systematic account of when and why and how often they [glide]." His studies thus far have been in a controlled setting; he's only seen a snake glide in the wild once. He was on a wildlife observation tower in the forest and he saw a flying snake on the edge of the tower. When he moved toward it, it jumped off and glided to some trees. "That was definitely an instance of predator avoidance—it was trying to escape from me—and I presume this is one of the reasons they use it in the wild."

Tim MacMillan/John Downer Pro/naturepl.com

In this composite photo, a Kuhl's flying gecko (*Ptychozoon kuhli*) descends from a tree.

Future Fliers

There may be dozens or even hundreds of species of arboreal vertebrates in Southeast Asia and elsewhere whose gliding behavior has not yet been discovered by scientists, because these species lack obvious physical modifications to call attention to their abilities. Some of these animals may eventually evolve physical characteristics that make them better gliders. It's unlikely that any of them will evolve into fliers, however.

Take *Draco*, for example. Even though they already have wings, the wings have scant musculature. The wings of birds, bats, and pterosaurs are all modified forelimbs and, as such, come with relatively powerful muscles of the sort that would be needed for active flight.

"To become a glider is difficult, but evolving active flight is far, far more difficult," Socha says. "And part of the evidence of that is that it has only happened four times in the history of life."Z

—Mary-Russell Roberson last wrote about oak forests in the July/August issue.

Native Americans hold sacred the peaks atop San Francisco Mountain near Flagstaff, Arizona. Conservationists have joined 13 Native American tribes in a court battle to protect the peaks from further development.

sacred spaces.

PROTECTED PLACES

by Brendan Borrell

The creation story of the Hualapai tribe tells of a great flood that swept across the desert. As the waters rose, one family placed their daughter in a hollow log and sealed it with pine pitch. The girl floated across this ancient sea and came to rest atop the peaks of San Francisco Mountain, the jagged remains of a massive volcano just north of Flagstaff, Arizona. Thereupon, she conceived two sons, the deities from which the tribe has descended.

Five years ago, the Hualapai faced a second deluge. The Arizona Snowbowl ski resort has been in operation on the tallest of the peaks, Humphrey's, since 1938, and has been gradually expanding operations ever since. San Francisco Mountain is officially managed by the U.S. Forest Service (USFS), and in 2002, the Snowbowl's owners applied to purchase approximately 150 million gallons of reclaimed wastewater from the Flagstaff sewage treatment plant each year, freeze it, and spray it on their ski runs. The Hualapai were not pleased. Nor were the 12 other Native American tribes who also consider the peaks sacred. They collect water from the region's creeks, harvest the mountain's medicinal plants, and conduct ceremonies on its slopes.

"The mountain can be seen on the horizon in the four sacred directions," says Robert Tohe, a Navajo who works for the Sierra Club. In the last year, he has visited San Francisco Mountain seven times, and he still remembers his first trip with his parents 50 years ago. "As you approach the mountain from any direction," he says, "You realize the power and the magnitude of the strength that emanates from it."

Frans Lanting/lanting.com

Hawaiian chiefs long ago designated Kilauea Volcano on Hawaii *Wahi Kapu*, meaning sacred and worthy of protection.

From its base in the Sonoran Desert, San Francisco Mountain rises up to 12,633 feet through the seven life zones first identified by naturalist Clinton Hart Merriam in the 1880s. As the barrel cacti and prickly pear thin, the valleys fill with ponderosa pine. Climbing higher, Merriam found Douglas fir, then bristlecone and spruce. The summit is alpine tundra—a small piece of the Arctic in the desert Southwest.

Tohe remembers Navajo elders taking up arms when a group of developers first proposed to expand Snowbowl on their sacred mountain in 1969. The developers wanted to turn the ski area into what the Sierra Club's Andy Bessler calls, "the next Aspen." In a devastating blow, the courts ruled against the tribes and in 1979, the USFS approved the construction of four new ski lifts, a paved road, a larger parking area, and a new ski lodge.

The region is not naturally suited to winter recreation. The first Spanish explorers had christened the peaks *Sierra Sin Agua* ("mountains without water"), and in the last several years snowfall has been marginal. Attempts to produce man-made snow were hampered by a dearth of groundwater, so the operators developed their wastewater plan.

This proposal was roundly endorsed in 2005 by the USFS, which saw no conflict with tribal beliefs or environmental concerns. Bessler, however, says there is growing evidence that chemical pollution in wastewater, ranging from caffeine to antibacterial soap, can have profound effects on wildlife. "These studies are ongoing," he says, "and a lot of this is really new science." He notes that reclaimed wastewater contains a class of chemicals called endocrine disrupters—primarily estrogen mimics—that disrupt the sexual development of animals ranging from amphibians to mammals.

Following the decision by the USFS, the Sierra Club and the Center for Biological Diversity joined forces with the tribes to challenge the proposal in court. In March of this year, three judges in the Ninth U.S. Circuit Court of Appeals ruled unanimously that the snowmaking plan hindered the ability of Native Americans to practice their religion, a clear violation of the Religious Freedom Restoration Act. The tribes' attorney, Howard Shanker, said, "We've established a substantive basis for Native Americans to protect sacred sites."

But the battle has not ended. Shanker and the tribes are preparing for a possible rehearing, which was filed by the U.S. Department of Justice on behalf of the USFS on May 30 and would involve 15 judges from the Ninth Circuit Court. In a statement posted on the Arizona Snowbowl website, Eric Borowsky, a general partner at the resort, says he intends to take the matter all the way to the U.S. Supreme Court, "to insure once and for all that radical groups who hold utter contempt for the public's rights will no longer be able to abuse the process to achieve their ultimate goal of control of our nation's resources."

Around the world, sacred lands that have been protected by indigenous peoples for centuries are under siege, and conservationists and anthropologists are developing strategies to protect them. Scientists estimate that 12 percent of the Earth's land surface is formally protected as national parks or other management areas. Yet in many countries, regulations are rarely enforced and local people who depend on natural resources from these areas will continue to do so. Most protected areas are located in places that provide few economic resources to local people—mountaintops, for example—while the biodiversity in fertile valleys has typically been supplanted for agriculture. Sacred sites offer an opportunity to preserve native biodiversity in these agricultural landscapes and other threatened regions with the cooperation of local people. Conservation biologist Shonil Bhagwat of the Natural History Museum in London says sacred sites are crucial because

Around the world, sacred lands that have been protected by indigenous peoples for centuries are under siege, and conservationists and anthropologists are developing strategies to protect them.

"they offer habitat to species where they would otherwise not be able to survive."

But conserving these sites poses a number of problems. Many of these lands are not widely publicized or documented, and some may even be kept secret. Indigenous peoples are often oppressed and ignored by their governments, which compromises their ability to maintain the integrity of their land.

And as these people modernize and disperse, they lose their languages, cultures, and inevitably their ties to the landscape. In some cases, such as large-scale pilgrimages in sensitive areas or the commercialization of medicinal herbs, religious practices may inadvertently harm the landscape.

Lynn M. Stone/naturepl.com

Snow leopards inhabit sacred areas in the Himalayas.

Wahi Kapu

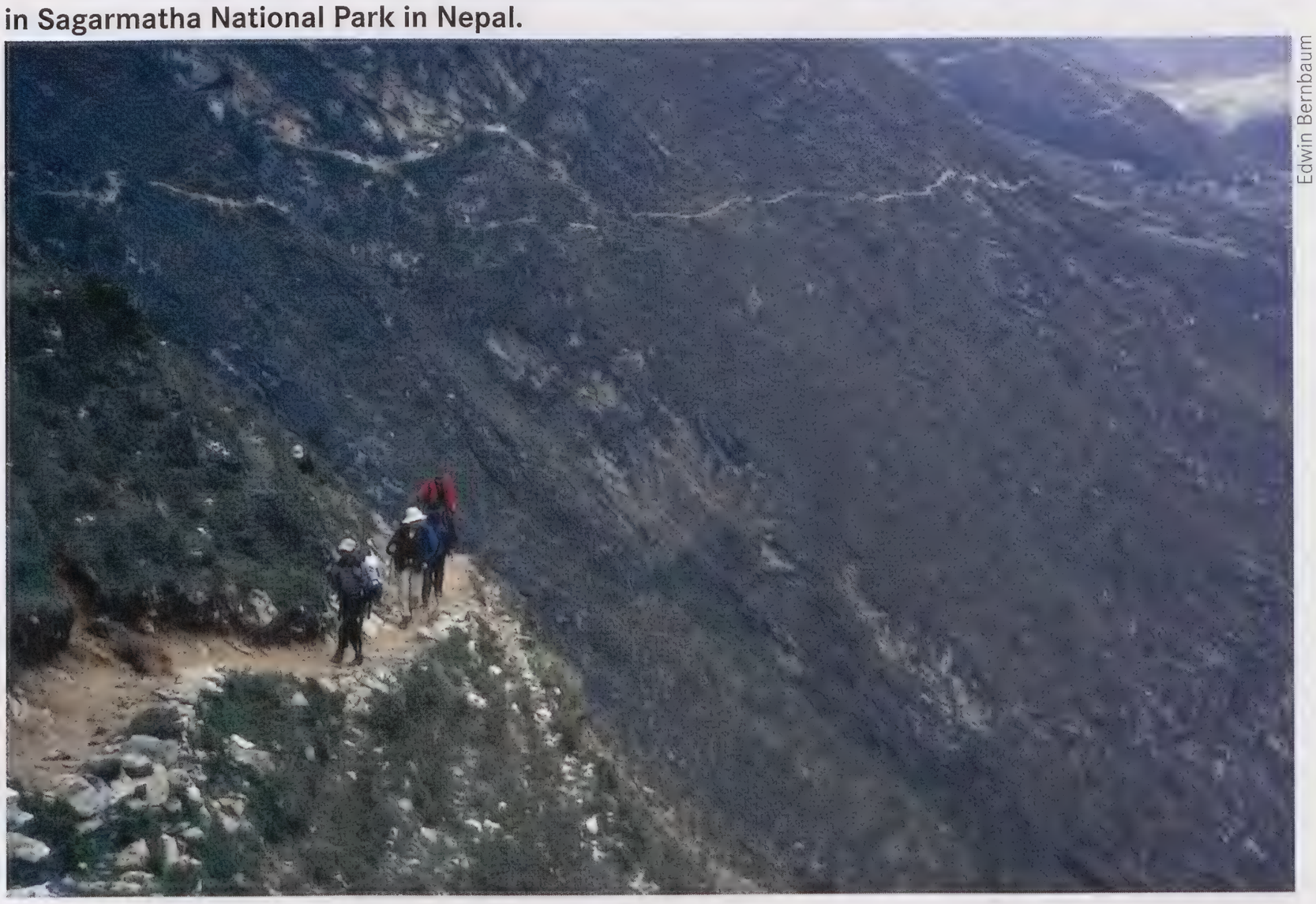
Upon visiting the Tonga people in Polynesia in the late 18th century, British explorer Captain James Cook took note of their behavior. He found the islanders friendly, but they always refused his offers of food or a seat at his table. Cook wrote in his journal, "When any thing is forbidden to be eat, or made use of, they say, that it is taboo." The concept of taboo was broadly applied across Polynesia. In New Zealand, 1,200 miles to the south, Maori priests declared a fishery or forest *tapu* to protect it from overexploitation. Edwin Bernbaum, a climber and religious scholar, says that Hawaiian chiefs declared mountains like the Kilauea Volcano Wahi Kapu, a sacred place, to prevent the citizenry from incurring the wrath of Pele, the goddess of fire. The more imminent threat to those who violated a *kapu* was corporal punishment and, in some cases, death. To this day, the word kapu is placed on private property signs in Hawaii to ward off trespassers.

Bernbaum is the director of the Sacred Mountains Program at The Mountain Institute. He is a bearded man in his early 60s who has a casual way of speaking about a landscape he reveres. In the 1960s, he was a volunteer for the Peace Corps in Nepal. After his service, he joined an expedition to a peak in the rugged Annapurna Sanctuary; on the way in, the locals were grumbling about landslides, which they claimed were caused by Western women who were trekking in the sanctuary. Sure enough, during the hike, Bernbaum was caught in an avalanche, swept 1,000 feet down the face, and buried in snow. A month after recovering, he hiked to Kathmandu with a Buddhist monk, who opened Bernbaum's eyes to the traditional beliefs surrounding the mountains. These beliefs are part of a complex theology that also prohibits bringing meat and eggs into the sanctuary. While Himalayan valleys have been degraded significantly over thousands of years of human exploitation, reverence for sacred mountains has helped preserve their alpine ecosystems.

Working with Ang Rita Sherpa at The Mountain Institute, Bernbaum has consulted on the Sacred Sites Trail that follows a circular route passing through monasteries, caves, hermitages, and nunneries in Sagarmatha National Park, the gateway to Mount Everest. Beginning in 2003, Ang Rita designed the trail around existing routes and has been helping to restore and protect both man-made and natural sites along the way. The trekking boom around Everest has helped boost the local economy, but it has also degraded the region's fragile environment and weakened cultural traditions. Bernbaum thinks conservationists can only go so far with regulatory approaches, and they need to begin asking "What is the importance of these places in contemporary society, and how can people develop some understanding and appreciation so they don't negatively impact them?"

Throughout the Himalayas there is essentially a contour line at 14,000 feet, and everything above it is sacred to both Buddhists and Hindus. At these altitudes, trees are confined to moist canyons, and the densest vegetation is typically a lichen clinging to a cliff face. Creatures like the snow leopard (*Uncia uncia*) and the

The Sacred Sites Trail takes trekkers past monasteries, hermitages, and other hallowed spots in Sagarmatha National Park in Nepal.



Edwin Bernbaum

David Noton/naturepl.com

Among the sacred peaks in the Himalayas is Mount Machhapuchhre, also called Fishtail Mountain, in Nepal's Annapurna Sanctuary. Mountain climbers are forbidden to summit it.

bharal, or blue sheep (*Pseudois nayaur*), still find refuge in these sacred mountains. Below this contour line lies a patchwork of sacred groves stretching from the Nepalese and Tibetan highlands through India.

The Mountain Institute has been working in this area with the World Wildlife Fund (WWF) on a larger project, the Sacred Himalayan Landscape, which aims to connect a mosaic of wild lands encompassing some 40,000 square kilometers (about 15,450 square miles), and to encourage sustainable management and local governance. Last September, with the support of the WWF, the Nepalese government turned over areas surrounding Kanchenjunga—the world's third-highest mountain—to a coalition of local communities.

But from a scientific perspective, the question is whether cultural practices actually protect biodiversity. In Tibet, ethnobotanist Jan Salick of the Missouri Botanical Garden has found that sacred groves harbor greater biodiversity and unique species than other intact forest sites. For millennia, Sherpas have engaged in intelligent land-use practices to ensure a sustainable supply of firewood and construction materials, but their religious beliefs have afforded even greater protection to these sacred forests. "Every time a new household is formed," Salick says, "they go out and designate a tree or a sacred area. Every time a living Buddha comes through, or one of the high lamas, people will ask them to designate new sacred sites." With eight sacred mountains in the area in which she works, Salick says the region has remained remarkably pristine. "Although sacred sites do seem to be ideal conservation vehicles," she warns, "they have a much deeper meaning to people in the area, and we have to realize we're tapping into something more fundamental in their cosmology."

According to Bhagwat, between 100,000 and 150,000 sacred groves exist in India alone. "They can be as small as a backyard garden to as large as Central Park in New York," says Bhagwat, who works in the moist tropical forests of the Western Ghats, a long mountain chain in southwestern India. These groves go back a thousand years and, Bhagwat speculates, "People probably realized that unless they had batches of native forest they wouldn't have these birds and insects and biodiversity around them." He says that the groves represent a link to the spirit world, but they also provide habitat for medicinal herbs and plant species that are uncommon elsewhere.

It is not just the size of the groves that is important; their spatial distribution around the country allows them to act as unique reservoirs for threatened plants and wildlife throughout the country. In Kodagu District, Bhagwat has documented threatened tree species in these groves that are not found in formally protected areas. In one grove, he remembers spotting the elusive Malabar trogon (*Harpactes fasciatus*), a cinnamon-colored bird with a throaty call. In the town of Madurai in southern India, Indian flying foxes (*Pteropus giganteus*)—which are hunted for their body fat—find respite in the ancient groves at four sacred sites. Although the total

area of India's groves is small—0.01 percent of the country—they make up a system of wildlife corridors that will play an important role in the coming years as species' ranges shift due to climate change.

In some cases, sacred sites are not attractive to wildlife. Peter Leimgruber, a mammalogist at the Smithsonian's National Zoo, has been using satellites to track the movements of endangered Asian elephants (*Elephas maximus*) in the muddy jungle of Alaungdaw Kathapa National Park in Myanmar. The largest park in the country, Alaungdaw Kathapa is named after Maha Kathapa, a 13th-century Buddhist monk from India who traveled through the region and is credited as an early conservationist. On his pilgrimage back to India, Kathapa is said to have died in his sleep in a cave near a river. Soon after, the cave closed over him. In the dry season, when the river is low enough that it's possible to enter his shrine, some 30,000 pilgrims come to pay their respects.

"It's in the center of the park," says Leimgruber, and people come in bush taxis and buses. Some high officials arrive in helicopters. For almost two years starting in 2002, Leimgruber followed the movements of one elephant, Silver Moon, until the battery in her transmitter died. Silver Moon tended to avoid the edges of the park and the rough track that leads to the shrine. "Wild elephants will avoid areas with a lot of human activity," Leimgruber says.

The story has parallels in other parts of the world. A pilgrimage called Romeria del Rocío that takes place on the seventh Sunday after Easter brings hundreds of thousands of Catholic pilgrims to the Andalusian town of El Rocío by way of Doñana National Park, where they trample vegetation and leave trash in their wake. The Huichol people of Mexico's Sierra Madre Occidental undertake a yearly pilgrimage down to Wirikuta, a 1,200-square-mile area in the Chihuahan Desert that is also a victim of its own popularity. With summer temperatures exceeding 100°F, Huichols say this desert is the land where the sun was born. Each year they hike several hundred miles to the site, which is in the state of San Luis Potosi, along ancient routes in order to eat sacred peyote cacti and communicate with their deities and ancestors. But because Wirikuta lies outside their homeland, the Huichol have little power in preserving the site or the ancestral paths that are now situated on a patchwork of private land. In recent years, cattle fences have gone up along the way and commercial collectors have decimated the region's diverse populations of cacti, threatening this tradition. In other parts of the world, particularly Tibet, sacred lands with medicinal and psychotropic plants are being exploited for the Chinese market and beyond.

Saving Grace

Although there are a number of isolated cases where religious practices indirectly harm biodiversity, no one interviewed for this story specifically blamed religious teachings. "Tribal culture," says Bessler, "has environmental protection as a core tenet." The real problem seems to be that indigenous peoples are losing their cultural connection to the landscapes.

Bhagwat says that the sacred groves in the Western Ghats are threatened by an influx of coffee workers and other immigrants who do not have the same values or traditions as the locals. Powerful plantation owners often allow these workers to make temporary shelters in sacred groves. In lean years, native trees may even be harvested by the owners themselves, only to be replaced by fast-growing exotics. Ownership of the groves is no longer in the hands of the local communities but the governments, which frequently have a hand in logging operations.

Adding to this problem is the fact that few sacred lands are officially protected. Salick says that families rarely share the location of their sacred groves for fear that a disgruntled neighbor may go and chop them down. "That destroys their personal family relationship with the universe," she says. Gonzalo Oviedo, a senior advisor at the World Conservation Union (IUCN), says that in Africa and Latin America, people have learned to conceal these sites, because of a long history of missionaries who destroy them in an attempt to eliminate idolatry and animism.

Even in the United States, land managers are not doing enough to identify and catalog the sacred sites of Native Americans, says Kieran Suckling, a policy director at the Center for Biological Diversity in Tucson, Arizona. "The agencies don't find out that these sacred sites exist until after they propose to destroy them,"

A sacred grove dedicated to the Hindu goddess Chamundi in the village of Mythadi, Kodagu District, in India's Western Ghats. Local deities in India's sacred groves are being displaced by Hindu deities.

Claudia Rutte

Edwin Bernbaum

Near the Sherpa village of Phortse are sacred groves, caves, and meditation huts.

he says. "They spend hundreds of millions of dollars every year discovering and mapping minerals that are thousands of feet below ground. How hard would it be to find sacred sites above ground?"

Many conservationists think that the key to preserving the sites may be to empower the people themselves. Bernbaum mentioned a modest project at a temple in Badrinath, a holy Hindu town on the Indo-Chinese border. This site has a small pilgrimage tradition dating back to the ninth century C.E., but as road access improved following the Indo-Chinese War in 1962, the region began receiving half a million pilgrims each year. It is named for the once-plentiful walnut, or Badri, trees that have all but disappeared there. Since 1993, the Pant Institute for Himalayan Development has provided some 14,000 native seedlings, which the monks incorporated into a tree-planting ritual during the pilgrimage. The project has since ended, but it speaks of the power that cultural practices may have on the future of biodiversity conservation.

This approach may also help locals become involved in conservation outside of traditional sacred sites. In the Udaipur district in northwestern India—a region known for its lakes and rivers—the forest department had grown frustrated with local people flouting regulations it had in place to conserve a patch of forest. It turned out that local people had their own way of protecting forests, a system that relied not on governmental regulation, but on a small bowl of saffron-laced water. When the forest managers adopted this system, termed *kesar chirkav*, by sprinkling saffron around the forest, villagers began to respect the boundaries of the newly protected forest.

A Tibetan lama.

Edwin Bernbaum

Perhaps the most ambitious effort was announced in March by the United Nations Environment Programme (UNEP). The new initiative, Conservation of Biodiversity Rich Sacred Natural Sites, will fund the preservation of sacred sites around the globe with the help of conservation organizations and indigenous peoples groups. Gonzalo Oviedo is leading the project for the IUCN and has received requests for support from the people of the Boloma-Bilagos archipelago of Africa's Guinea-Bissau, the pilgrims at Mexico's Wirikuta, and the inhabitants of Kodagu district of India. "The elders who normally manage the sites," he says, "worry that transmission of those values might be lost." Many of these groups are just requesting help in marking their groves, but others need assistance improving regulation and training young people. "Of course, we know the younger generation is not going to be the same as the elders," he says, but many are still concerned about protecting these areas from destruction and developing sustainable ways to use their lands.

Oviedo says one successful example of a multipronged approach is the Vilcanota Spiritual Park in southern Peru. The Q'eros people live in this diverse montane landscape high in the Andes, and for ages prohibited hunting and agriculture in the part of their land they used for traditional ceremonies. Unfortunately, these practices eroded as the people were confined to a smaller indigenous reservation, and as they shifted from subsistence agriculture to growing commercial produce. Oviedo says the Asociación Kechua Aymara para Comunidades Sustentables is working with UNEP to help the Q'eros combine modern agricultural practices with their traditional land use so that they will be able to survive in a market economy without degrading their landscape.

And soon, the Huichol will not have to worry about the future of Wirikuta. Oviedo says the organization Conservación Humana recently succeeded in doubling the size of the cultural reserve set aside by the state government of San Luis Potosi. The group is also installing gates in cattle fences along the pilgrimage route leading back to the Huichol homeland in the Sierra Madre Occidental. Oviedo expects parts of Wirikuta to be revegetated to prevent erosion, and it should also be fenced to keep livestock out of sensitive areas. He also says that the Huichol are interested in developing controlled ecotourism in parts of the park, which will help fund its management.

There is some indication that these strategies are already working. The sacred groves of Kodagu had been receiving some support prior to the announcement of the UNEP initiative, and Bhagwat says these small efforts have made a big difference. "I went to Kodagu last December," he says. "I visited some of the… sites where I had done sampling before. It seems that nothing much had changed in terms of the sacred grove itself. I also noticed fences around some groves that local temples had erected. That was their way of saying 'we value our groves and want them to be recognized.'"Z

—Brendan Borrell is a science writer based in Brooklyn, New York.

A Hop Through Australia

Chasing Kangaroos: A Continent, a Scientist, and a Search for the World's Most Extraordinary Creature
Tim Flannery. 2007. Grove Press, New York. 258 pp., hardbound. $24.

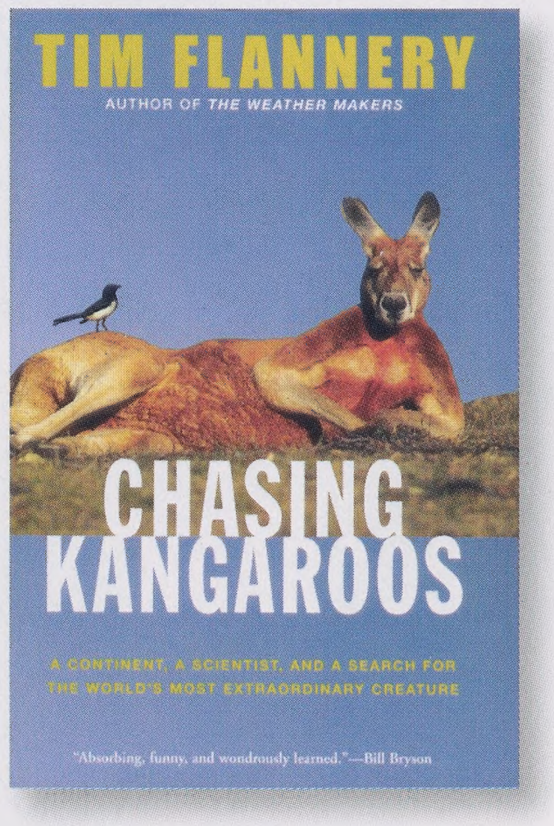
I've always found kangaroos vaguely menacing, repellent enough to put Australia toward the bottom of my list of places to go. Check out the dude on the cover of *Chasing Kangaroos*. Is it just me, or does he look like a Mafia don, what with his jowls, frown lines, and heavy-lidded stare, his languid posture belying a 200-pound boxer's toughness? I still picked up the book—admiration for its author, Australian Tim Flannery, overcame my distaste for its subject.

Four features unite these diverse species, which, surprisingly, are not closely related to other living marsupials. One is hopping and, associated with this, rigid ankles. Another is an unusual arrangement of the male external genitalia. The third is a large hole in the jawbone where a cheek muscle enters and attaches to the jaw, giving the cheek teeth great force. Finally, a female kangaroo is "forever barefoot and pregnant." While nursing one infant, she is pregnant with the next.

The cover animal is a red kangaroo, largest of the living marsupials, symbol of Australia, and the species most Americans picture as "the kangaroo." In fact, there are 70 or so different living species of kangaroos (and many more extinct forms), including three other large ones—all slimmer and daintier-looking than the reds, more boulevardiers than bruisers. At the other end of the size spectrum are diminutive musky rat kangaroos, rabbit-like one-pounders with big eyes. And in between is a diverse assortment of kangaroos called wallabies, pademelons, bettongs, potoroos, and quokkas.

Chasing Kangaroos is full of fascinating stories about kangaroo species, living and extinct, told with wit as well as the wonder with which Flannery views these creatures. A chapter on extinct Ice Age species describes long-necked giant wallabies that resembled giraffes, huge short-faced kangaroos eerily like hominids, and even a carnivorous "killer kangaroo." Flannery discovered the killer kangaroo—and many more species living and extinct—and writes about the thrill of it: "Then there were a delicious couple of days when, as I worked on my theory without telling anyone else, I was the only person on Earth who knew that great, carnivorous kangaroos once stalked Australia."

Of the news about living kangaroos I was most astounded by their digestive system (really!). Like cows, kangaroos eat grass but can't digest it. Instead, cow guts harbor symbiotic, microscopic bacteria that break down the tough grass. Kangaroos have a similar system with one huge difference: Their digestion assistants are worms, "as thick as a hairpin and twice as long." In essence, the kangaroos eat grass in order to feed their worms, whose byproducts feed the kangaroos. How cool is that?



But this book is not only about kangaroos. In often hilarious stories of his adventures in the field, replete with a host of colorful characters, Flannery, now a professor at Macquarie University in Sydney, describes his career as a paleontologist obsessed with finding the fossils that would help him understand how kangaroos came to be. Like many of the Australians (and paleontologists of any nation) in these tales, Flannery is a bit of a character himself. The first sentence of the book is, "When I was a young man I met a man whose arse bore the bite-mark of a Tasmanian tiger."

Young people will be inspired by the fact that Flannery's high-school record was too poor for admission to a college science program—he got his start as a volunteer in the Museum Victoria in Melbourne—and today he is among the most renowned scientists in the world. In addition to his specialized scientific writing, Flannery contributes regularly to *The New York Review of Books*, and is the author of acclaimed books for the general public, including environmental histories of Australia (*The Future Eaters*) and North America (*The Eternal Frontier*), and, most recently, *The Weather Makers*, about the causes and effects of climate change.

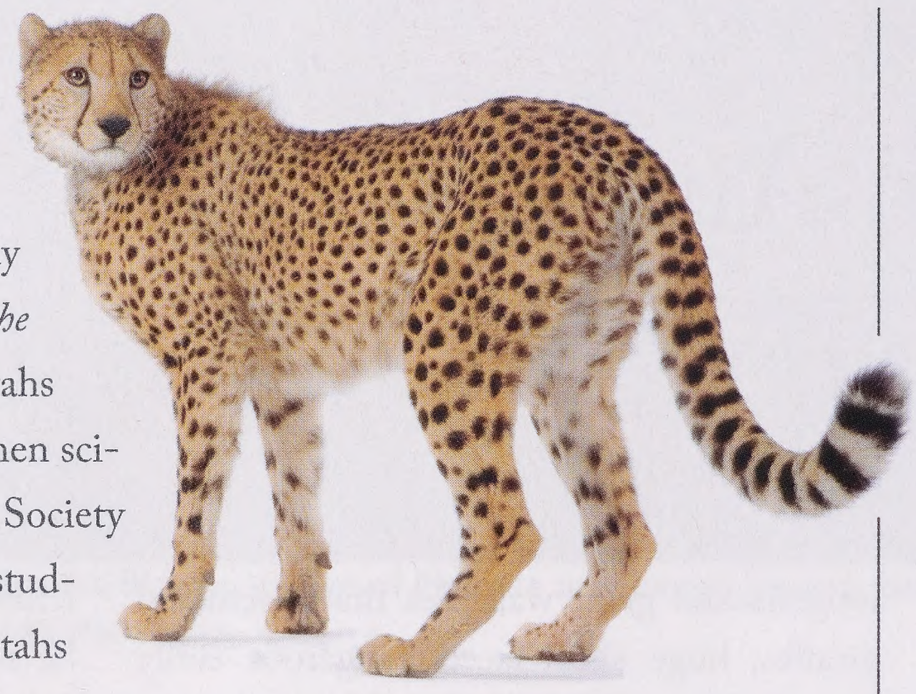
In *Chasing Kangaroos*, Flannery also offers an ecological history of Australia to show how the evolution of kangaroos is inseparable from the environments in which they lived, and ends with a plea for the conservation of this damaged land and its diminished fauna. Many of the kangaroo species he discusses are highly endangered, and other Australian marsupials are extinct. The last Tasmanian tiger died just before Flannery was born. In referring to the animal's bite-marks on the arse of a man he once knew, Flannery writes, "In my youthful imagination that scar was the supreme stamp of Australian identity, a badge of honour that lay forever beyond my reach."

Flannery concludes "with a sinking feeling...that things are likely to end badly for both ourselves and this great island continent," unless every Australian helps to save it. If anyone can, Flannery will help to inspire this, and not only among Australians.

—Susan Lumpkin

BIOALMANAC
by Alex Danoff

Cheating Cheetahs

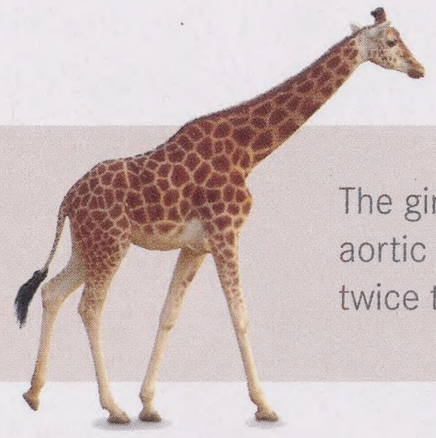


It has long been assumed that male felids are sexually promiscuous. But a study published in May in the *Proceedings of the Royal Society B* revealed that female cheetahs (*Acinonyx jubatus*) play the field, too. When scientists from the Wildlife Conservation Society and the Zoological Society of London studied DNA extracted from the feces of cheetahs living in Serengeti National Park in Tanzania, they found that 43 percent of litters with more than one cub were fathered by more than one male. The study demonstrates that female cheetahs are polyandrous, meaning they have multiple mates at a time.

Unlike other wild felids such as tigers, female cheetahs have relatively large territories in which they may encounter several unrelated males, and are not monopolized by a single male. Although polyandry heightens their risk of contracting parasites and sexually transmitted diseases, the benefits seem to outweigh the risks. Mating with multiple partners increases their cubs' genetic diversity, and may also deter males from committing infanticide, a common practice among big cats, because males are less likely to kill cubs that might be their own.

What's in a Name?

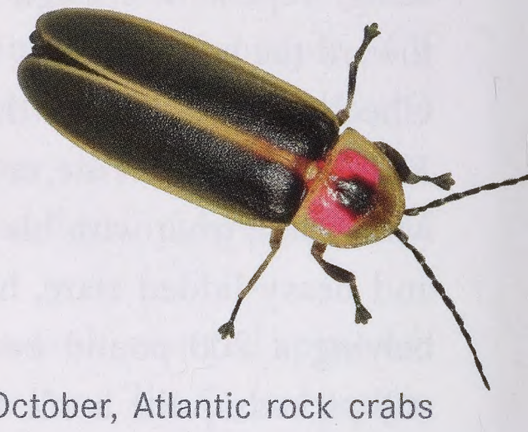
The ten species of skunks, which are native to North and South America, get their common name from their famous–and malodorous–defense mechanism. "Skunk" likely derives from the Algonquian word *sekakwa* and its roots *sek*, meaning "urinate," and *akw*, meaning "fox"–a reference to the small carnivores' ability to spray fluid from glands near their tail when provoked. Some skunks' scientific names follow suit. The genus *Mephitis*, for example, comes from the Latin word for "stench," and the eastern spotted skunk's name, *Spilogale putorius*, is a combination of Greek and Latin words that mean "stinking, spotted weasel." Skunks' smelly reputation is so pervasive that "skunk" is often used to describe things that are foul-smelling or unpleasant. Skunk cabbage, for example, is a pungent plant that grows in wetlands across North America. And if you are called a skunk, you are likely seen as an obnoxious or disliked person.



The giraffe has the highest blood pressure of any mammal. Its central aortic pressure can be as high as 250 millimeters of mercury, roughly twice that of the average human adult.

Why Do Fireflies Flash?

In the vast majority of fireflies, males and females flash to attract mates. The timing of their flashes is species-specific, so females can recognize males of their own kind. But for females in the genus *Photuris*, flashing is predatory. They mimic the alluring signals of *Photinus* females, and when eager *Photinus* males land beside them, they kill and eat them. Two fireflies in the southern United States take flashing to another level. In late spring and early summer, male *Photinus carolinus* and *Phoruis frontalis* light up in unison, creating a dazzling spectacle for observers. Scientists aren't sure why, but the synchrony may be part of a complex mating ritual.

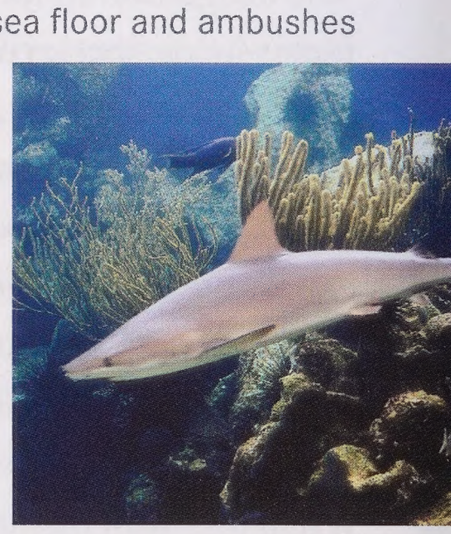


In Season

In September and October, Atlantic rock crabs (*Cancer irroratus*) begin their reproductive season. In autumn these mobile scavengers, which live along North America's East Coast, stay at shallow depths, where the females prepare themselves for mating by moulting their shells. After mating, females store their fertilized eggs in their bodies for nearly a year, then release their larvae the following summer. By fall, the larvae develop into tiny crabs called megalops, which stick to the shallows to avoid the many predators that feed on them.

Fact or Fiction: All Sharks Must Swim to Breathe

Most open-water sharks must swim continuously to force water (and thus oxygen) over their gills, but bottom-dwelling species typically have muscles that propel water through their gills when they're still. This is crucial for sharks like the spotted wobbegong (*Orectolobus maculatus*), which hides on the sea floor and ambushes prey. Sharks lack a swim bladder to keep themselves buoyant; instead, many have an oil-filled, oversize bladder and swim continuously to achieve neutral buoyancy. The sand tiger shark (*Carcharias tuarus*), also called the gray nurse shark, has another method of staying afloat: At the surface, it swallows air that fills its stomach, allowing it to remain motionless without sinking.



Eric Isselée/iStockphoto.com. Common striped skunk (*Mephitis mephitis*): Erwin & Peggy Bauer/Bruce Coleman Inc. Giraffe: Martin Kraft/iStockphoto.com. *Photinus* firefly: David Cappaert/Michigan State University/Bugwood.org. Caribbean reef shark (*Carcharhinus perezi*): photos.com.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